AD-764 662

IONOSPHERIC MODELING

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Prepared for:

Office of Naval Research
Advanced Research Projects Agency

31 March 1973

Quarterly Technical Report no. 2

1 Jan - 31 Mar 73

IONOSPHERIC MODELING

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Contract Number: N00014-67-A-0220-0004

ARPA Order Number: 2266/8-11-72

Program Code Number: 3F10

1 October 1972 - 30 September 1973

$54,101

Scientific Officer: Director, Physics Program
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Department of the Navy
800 North Quincy Street
Arlington, Virginia 22217

Sponsored by
Advanced Research Projects Agency
ARPA Order No. 2266

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E and F Region (100-500 km)

The previous quarterly report reviewed the computer code that was developed to generate the E and F regions of the polar ionosphere. The results that are given in this report are outputs from that computer program.

The neutral atmosphere is generated from the atmospheric model of Jacchia (1971). Figure 1 shows the altitude distribution of the major neutral constituents based on an exospheric temperature of 1000°K. The variations of the atmospheric constituents with respect to time of day, solar cycle, etc., can be fed into the model by varying the exospheric temperature, which is an input to the computer program.

There are two processes which produce ionization in the 100-500 km height region of the polar ionosphere; solar photon absorption and energetic particle precipitation. For convenience these two mechanisms are further subdivided into daytime and nighttime photoionization, and auroral arc and electron "drizzle" particle precipitation.

Figure 2 illustrates the photoionization rates versus altitudes for the Jacchia neutral atmosphere. The daytime production rate is naturally a function of latitude, time of day and season; the conditions of Figure 2a were chosen for illustrative purposes. Figure 2b records the ion production produced during the nighttime by solar radiation scattered to the dark side of the ionosphere by the earth's hydrogen and helium geocorona. This process will be considered constant through the night until a three-dimensional photon scattering algorithm is obtained from Robert Meier of the Naval Research Laboratories (1973).

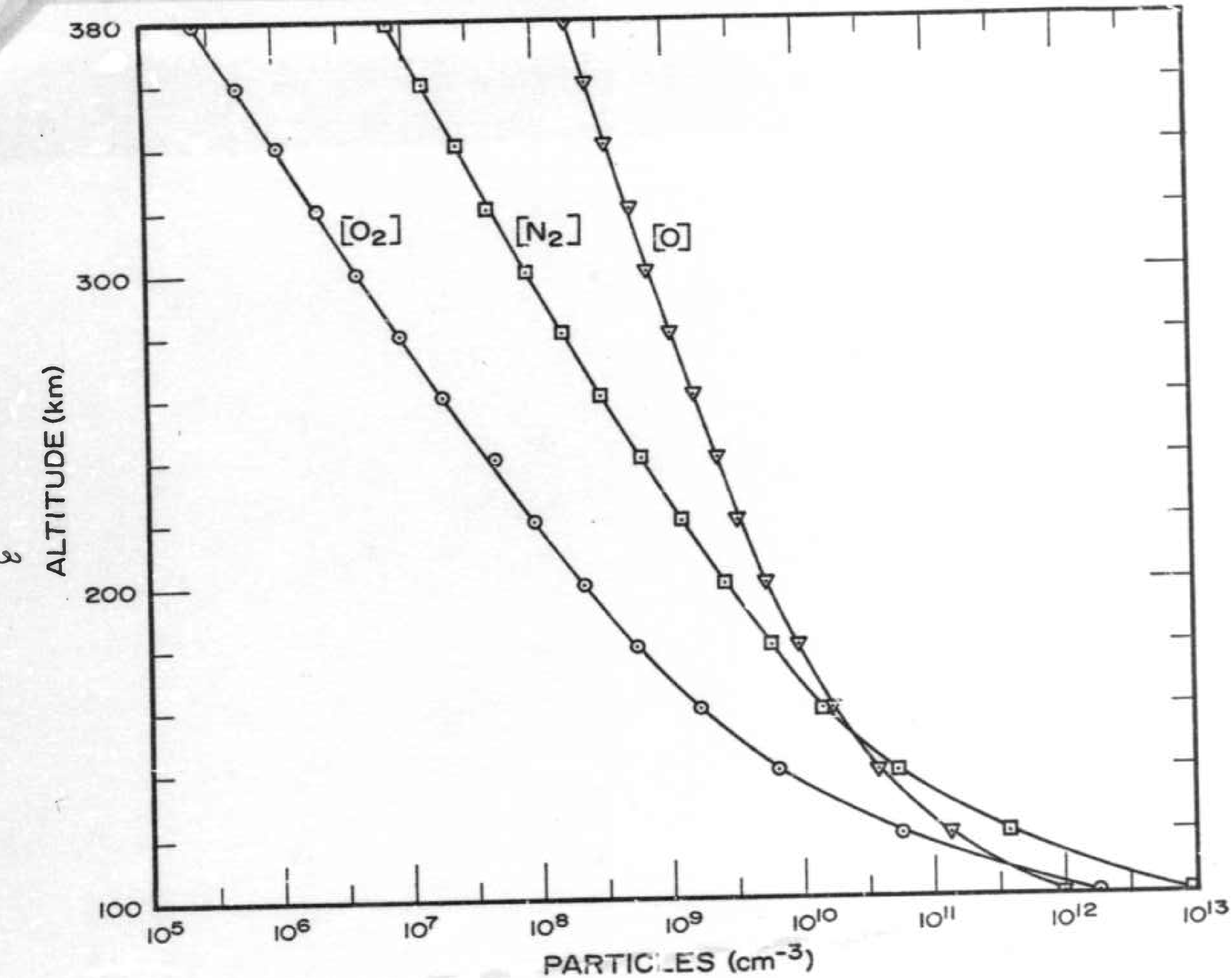
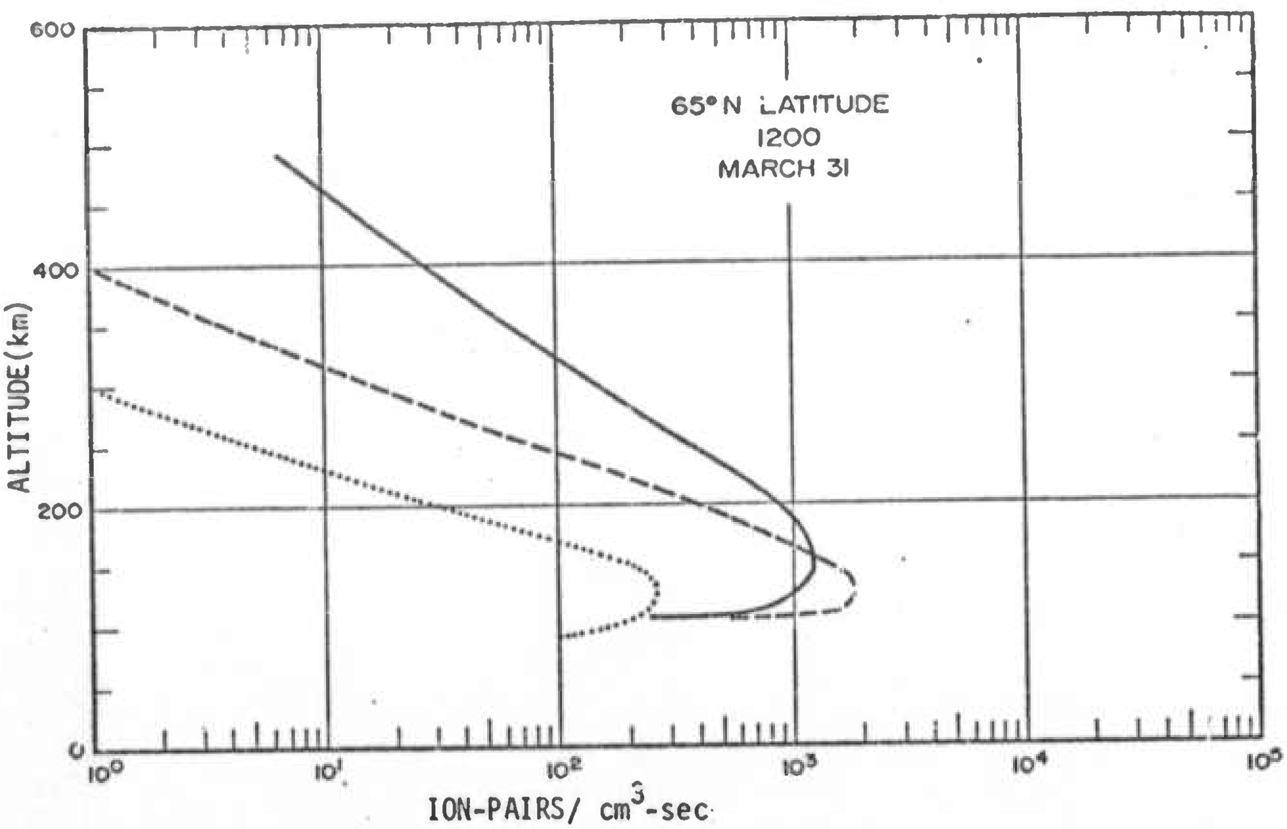
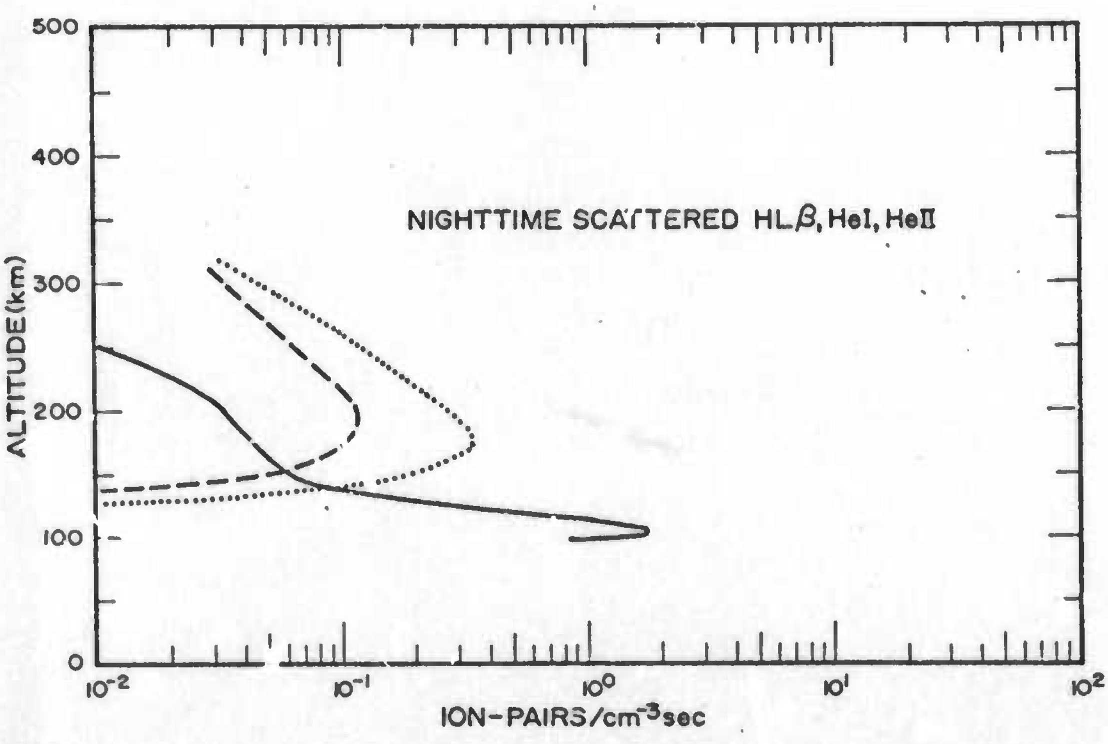

380
300
200
100
ALTITUDE (km)
$[O_2]$
$[N_2]$
[O]
10^5
10^6
10^7
10^8
10^9
10^{10}
10^{11}
10^{12}
10^{13}
PARTICLES (cm^{-3})

Figure 1



65° N LATITUDE
1200
MARCH 31
ALTITUDE (km)
ION-PAIRS/ cm^3-sec

(a)



NIGHTTIME SCATTERED HLβ, HeI, HeII
ALTITUDE (km)
ION-PAIRS/cm^{-3}sec

(b)

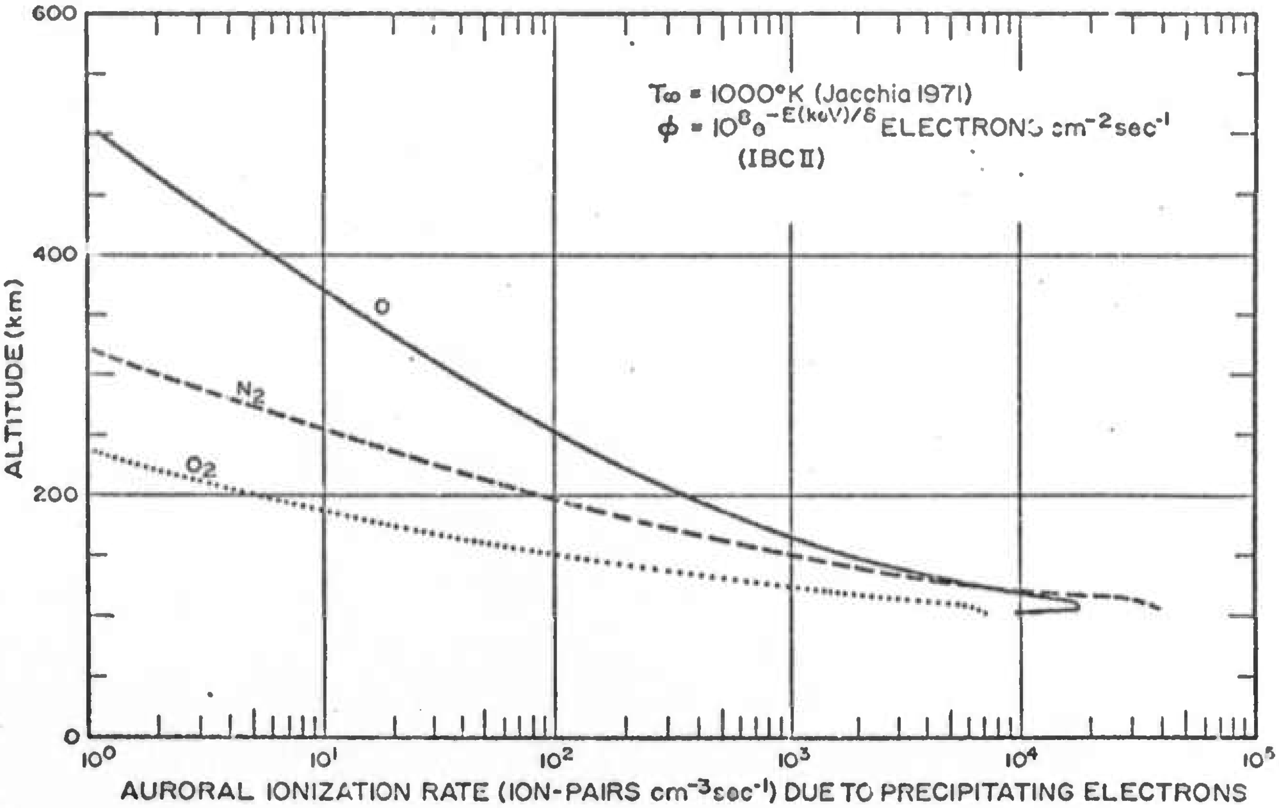
Figure 2

The ionization rate distribution produced by precipitating particles is given in Figure 3. The type IBC-II "standard" aurora (as defined by L. R. Megill, Utah State University; see Ionospheric Modeling Newsletter for April 10, 1973) produces ionization near 100 km at an order of magnitude higher rate than the noontime solar photon flux. The "drizzle" electron flux, which is characteristic of the polar cap and perhaps the whole quiet polar ionosphere, produces the ionization shown in Figure 3b. Figure 4 is a plot of the ion-pair production per air particle per incoming primary electron as a function of electron energy. This figure shows that the higher energy electrons drive deeper into the atmosphere before reaching their peak ionization rate. Since the atmosphere has an exponential density variation with height, the total production rate is weighted toward the lower altitudes as shown in Figure 3a and Figure 3b. It is obvious that the time and spatial distribution of precipitating particles is essential in the determination of the polar ionospheric distribution.

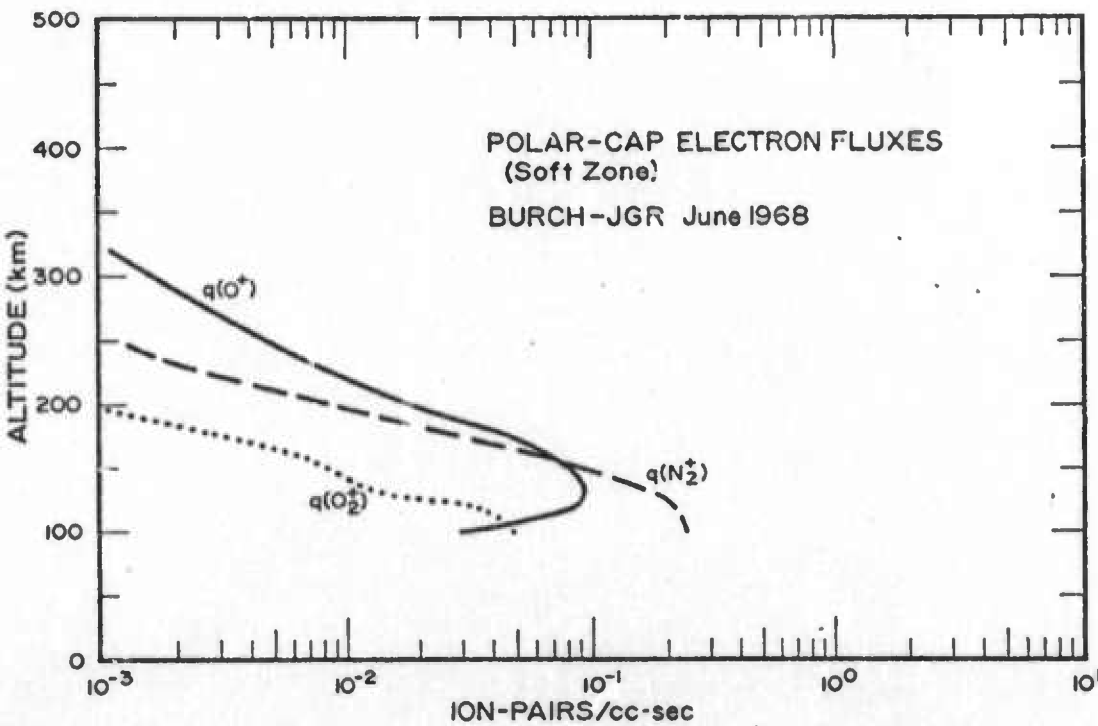
A copy of a computer code which would include the transport effects of vertical diffusion was found to have been superceded by a new code written by Mr. Earl Good of the U. S. Air Force Cambridge Research Laboratories (1973). This new code has been promised us but has not yet arrived. This will put our diffusion calculations behind schedule but we still hope to have a diffusion model working before the end of summer.

D Region (30-100 km)

Our philosophy for modeling the very complex D region was explained in the previous quarterly report. A subroutine to calculate the ion-electron pair production due to precipitating protons and alpha particles has been converted from the (PAMATRX) computed program discussed by Adams and


T∞ = 1000°K (Jacchia 1971)
$\phi = 10^{8} e^{-E(keV)/5}$ ELECTRONS $cm^{-2} sec^{-1}$
(IBC II)
ALTITUDE (km)
AURORAL IONIZATION RATE (ION-PAIRS $cm^{-3} sec^{-1}$) DUE TO PRECIPITATING ELECTRONS
O
N_2
O_2

(a)


POLAR-CAP ELECTRON FLUXES
(Soft Zone)
BURCH-JGR June 1968
ALTITUDE (km)
ION-PAIRS/cc-sec
$q(O^+)$
$q(N_2^+)$
$q(O_2^+)$

(b)

Figure 3

5

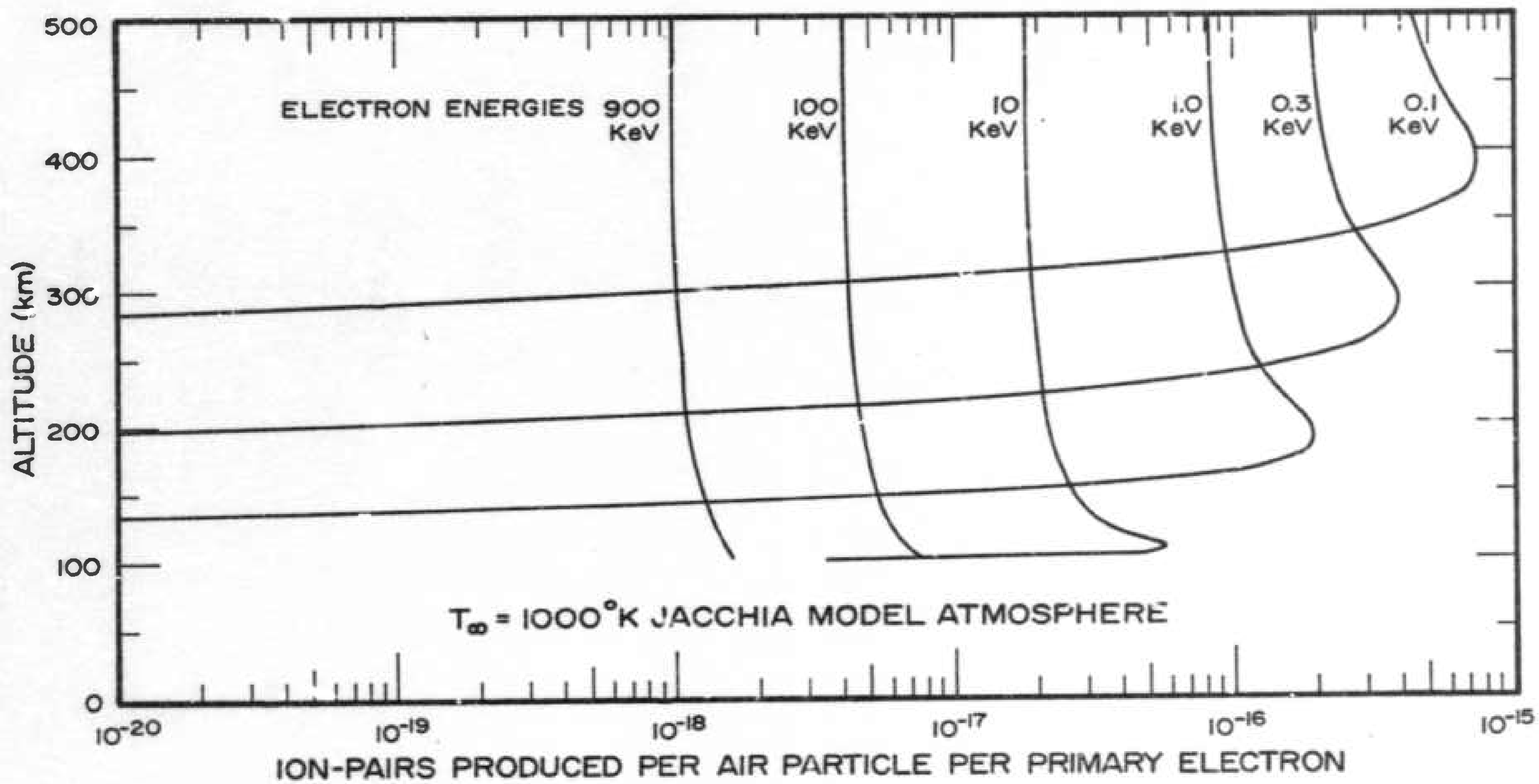

ELECTRON ENERGIES 900 KeV
100 KeV
10 KeV
1.0 KeV
0.3 KeV
0.1 KeV
T_∞ = 1000°K JACCHIA MODEL ATMOSPHERE
ALTITUDE (km)
500
400
300
200
100
0
10^{-20}
10^{-19}
10^{-18}
10^{-17}
10^{-16}
10^{-15}
ION-PAIRS PRODUCED PER AIR PARTICLE PER PRIMARY ELECTRON

Figure 4

Masley (1965). This program is also described in the Ionospheric Modeling Newsletter of May 10, 1973. The technique for calculating the D region ionization due to precipitating electrons is the same as that for the E and F regions described in the last quarterly report. However, the computer subroutine is being modified slightly to be compatible with the proton subroutine in order to conserve computer time. The final portion of the D region ionization is produced by solar photons. The solar flux has two major effects on the D region chemistry: first, the ionization of nitric oxide by Lyman α and second, the dissociation of heavy molecules by radiation of wavelengths greater than 1200 Å. We have found that if the detailed structure of the O_2 absorption cross section and the NO ionization cross sections are taken into account, then the solar flux in the 1030-1280 Å band may contribute as much NO^+ ionization as the Lyman α line at 1215.7 Å. This will be a very significant result since most D region models consider only Lyman α production. Spurred on by these results, we are now calculating the ionization rate of $O_2(^1\Delta_g)$ (an excited state of O_2) which might also contribute an additional 25% to the D region ionization production. Detailed results will be available for the next report. Modification of the E and F region photon production subroutines is being made to accommodate these latest results into a computer code for the D region. Once these production subroutines are complete, in the next quarter, the four-ion, steady-state model of the D region chemistry can be run to produce ionization profiles.

Literature Cited

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Good, E., Private Communication, 1973.

Jacchia, L. G., Revised static model of the thermosphere and exosphere with empirical temperature profiles, Spec. Rept. 332, Smithsonian Astrophysical Observatory, 1971.

Meier, R., Private Communication, 1973.